

**DATA QUALITY SUMMARY REPORT FOR  
BETA ATTENUATION MONITOR PM<sub>10</sub> MASS DATA  
COLLECTED BY SONOMA TECHNOLOGY, INC.,  
DURING THE CALIFORNIA REGIONAL PM<sub>10</sub>/PM<sub>2.5</sub>  
AIR QUALITY STUDY**

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## 1. INTRODUCTION AND OBJECTIVES

The purpose of this Data Quality Summary Report is to provide data users with an understanding of the quality of Beta Attenuation Monitor (BAM) PM<sub>10</sub> mass data collected by Sonoma Technology, Inc. (STI) for the California Regional PM<sub>10</sub>/PM<sub>2.5</sub> Air Quality Study (CRPAQS). **Table G-1** summarizes the operating sites and times for BAM PM<sub>10</sub> mass concentration measurements in CRPAQS. This report provides summary information on data completeness, lower quantifiable limit (LQL), accuracy, and precision. The BAM measured PM<sub>10</sub> concentrations (µg/m<sup>3</sup>) with 60-minute time resolution in standard temperature and pressure (STP) units. Data completeness was calculated for each site based on data delivered to the California Air Resources Board (ARB); the start date/time indicates the beginning of valid data, continuous until the stop date/time. Data validation suggested that all BAM instruments performed similarly; thus, Angiola was used as a representative site to calculate LQL, accuracy, and precision for all BAM PM<sub>10</sub> mass monitors operated by STI in the study.

As Table 1-1 indicates, valid BAM PM<sub>10</sub> mass data from the Angiola Trailer started on January 20, 2000; however, this instrument began operation at Angiola in December 1999. The data reported from December until January 20, 2000, was not of sufficient quality to deliver to ARB. For more information, please reference the quality control screening procedures documented by Hafner et al. (2003).

Table G-1. Location and duration of BAM PM<sub>10</sub> mass measurements performed by STI during CRPAQS.

Site	Start Date/Time	Stop Date/Time
Angiola Trailer	1/20/00 8:00 PST	2/6/01 9:00 PST
Bakersfield	1/21/00 23:00 PST	2/6/01 14:00 PST
Corcoran	9/13/00 15:00 PST	11/14/00 21:00 PST
Edwards	6/20/00 19:00 PST	9/1/00 6:00 PST

Several other documents can be referenced to obtain information about the CRPAQS field study and data processing. Sampling locations are described in Wittig, et al. (2003). Quality control screening procedures are summarized by Hafner et al. (2003). Results of systems and performance audits and intercomparisons are provided by Bush et al. (2001). The data quality objectives (DQOs) for BAM PM<sub>10</sub> mass from NARSTO documentation are shown in **Table G-2**. The BAM PM<sub>10</sub> mass measurements during CRPAQS met the DQOs for LQL, accuracy, and precision. A DQO for data completeness was not available.

Table G-2. Data quality objectives for BAM PM<sub>10</sub> mass data collected during CRPAQS.

Data Quality Metric	NARSTO Objective
Lower Quantifiable Limit	5 µg/m <sup>3</sup>
Accuracy	3%
Precision at < 80 µg/m <sup>3</sup>	5 µg/m <sup>3</sup>
Precision at < 80 µg/m <sup>3</sup>	7%

## 2. DATA COMPLETENESS

Data completeness for 60-minute BAM PM<sub>10</sub> mass sites is shown in **Table G-3**. Data capture quantifies the percentage of total records received versus the number expected during the “period of operation” defined by the start and stop dates/times in Table G-1; the start date/time is the first instance of valid data, and the period of operation is continuous until the stop date/time. The number of valid data points is divided by the number of captured data points to calculate the data recovery. Validity is defined for this calculation as any data point that has a quality control flag of V0 (valid) or V1 (valid but comprised wholly or partially of below-MDL data). Details of data validation are included in Hafner et al. (2003).

Table G-3. Data completeness values for BAM PM<sub>10</sub> mass (60-minute) at each site.

Monitoring Site	Total No. of Records	No. of Expected Records	Percent Capture <sup>a</sup>	No. of Valid Records	Percent Recovery <sup>b</sup>	No. of Suspect Records	No. of Invalid Records	No. of Missing Records
Angiola Trailer	9193	9194	100%	7873	86%	1018	109	193
Bakersfield	9159	9160	100%	8923	97%	49	129	58
Corcoran	1495	1495	100%	1435	96%	18	22	20
Edwards	1740	1740	100%	1666	96%	60	9	5

<sup>a</sup> % of capture = total number of records/expected records\*100%

<sup>b</sup> % recovery = number of valid records/total number of records

All sites had a 100% data capture rate. Data recovery rates ranged from 86% (Angiola) to 97% (Bakersfield).

## 3. LOWER QUANTIFIABLE LIMIT

The LQL is the lowest concentration in ambient air that can be measured when processing actual samples. Sources of variability that influence the monitored signal at low concentrations include instrument noise and atmospheric variability. As a measure of this variability, two times the standard deviation of selected 60-minute data was used to estimate the LQL. The selected data were collected during relatively stable periods with concentrations close

to zero. This is a conservative estimate of the LQL because it includes the concentration variability of the ambient air. Six data points were used with the 60-minute data, because atmospheric variation generally becomes too great after six hours to calculate a reasonable LQL.

The LQL is calculated as shown in Equation G-1. **Table G-4** shows the LQL, as well as the specific data strings used to calculate the LQL. The LQL meets the DQO.

$$LQL \approx 2s = 2\sqrt{\frac{\sum (BAM - \overline{BAM})^2}{N - 1}} \quad (G-1)$$

where:

$\overline{BAM}$  = meanBAM PM<sub>10</sub> mass concentration  
N = number of measurements  
σ = standard deviation

Table G-4. Time period used to calculate LQL, the LQL, and the corresponding mean concentration during the selected time period.

Time Period Used in LQL Calculation	LQL (µg/m <sup>3</sup> )	Mean (µg/m <sup>3</sup> )
1/11/01 2200 – 1/12/01 0400 PST	1.3	1.0

#### 4. ACCURACY

Calibration data for the BAM are not available since the BAM cannot be calibrated in a manner similar to instruments measuring gaseous species. Validation flow checks were performed periodically on the BAM PM<sub>2.5</sub>; these checks can be used to evaluate the accuracy of the flow through the instrument throughout the study. This technique quantifies the variability of the measured flow from the periodic flow checks. While not the true accuracy of the PM<sub>10</sub> concentration measured by the BAM, if most of the error is assumed to be due to flow changes, this method provides a sufficient surrogate.

Accuracy can be expressed in terms of the 95% confidence interval (CI). For BAM PM<sub>10</sub> mass measurements, the 95% CIs were calculated from the differences between the monitor's measured flow and the known flow provided by the flow checks. The 95% CI approximates the accuracy of the data as shown in Equation G-2.

$$\text{Accuracy} \approx 95\% \text{ confidence interval} = \frac{1.96 \left( \frac{s_{\text{flowcheck}}}{\sqrt{N}} \right)}{\overline{BAM}_{\text{flowcheck}}} \times 100\% \quad (G-2)$$

where:

$$s_{\text{flowcheck}} = \sqrt{\frac{\sum (x - \bar{x})^2}{N - 1}}$$

$$x = [\text{BAM}]_{\text{flowcheck}} - [\text{BAM}]_{\text{measured}}$$

$$\bar{x} = \frac{\sum ([\text{BAM}]_{\text{flowcheck}} - [\text{BAM}]_{\text{measured}})}{N}$$

$$[\text{BAM}]_{\text{flowcheck}} = \text{BAM PM}_{10} \text{ true flow as per flow check.}$$

$$[\text{BAM}]_{\text{measured}} = \text{flow measured during flow check by the BAM PM}_{10} \text{ mass.}$$

Periodic flow checks were performed at all sites; Angiola is used as the representative site for all BAM PM<sub>10</sub> mass monitors operated by STI during CRAPQS. The average flow measured during flow checks,  $[\overline{\text{BAM}}]_{\text{measured}}$ , was calculated by averaging the measured flows during the periodic flow checks. The 95% CIs and the number of flow checks used to estimate the CIs for BAM PM<sub>10</sub> mass at Angiola are provided in **Table G-5**. The accuracy computed using flow check data meets the DQO.

Table G-5. Accuracy and number of flow check data points used for the BAM PM<sub>10</sub> mass concentrations at the representative site, Angiola.

No. of Flow Checks Used	Accuracy
18	1.7%

## 5. PRECISION

Precision can be measured for the BAM PM<sub>10</sub> mass by evaluating the variance of PM<sub>10</sub> concentrations during a period of low variability, when atmospheric influence on variability is assumed to be minimal. Data collected during periods of low variability, but when concentrations were well above the LQL, were selected. The precision was then evaluated by calculating the coefficient of variation (CV) during the period of low variability, as shown in Equation G-3.

$$\text{Precision} \approx \text{CV} = \frac{\sigma_{\text{measured}}}{[\overline{\text{BAM}}]_{\text{measured}}} \times 100\% \quad (\text{G-3})$$

where:

$$\sigma_{\text{measured}} = \sqrt{\frac{\sum ([\text{BAM}]_{\text{measured}} - [\overline{\text{BAM}}]_{\text{measured}})^2}{N - 1}}$$

All the BAM PM<sub>10</sub> mass concentrations in Equation G-3 refer to the concentrations measured during the selected time period. **Table G-6** shows the precision calculated for the representative site, Angiola. The precision of the BAM PM<sub>10</sub> mass measurements at the reported mean meets the DQO.

Table G-6. Precision, the number of data points, time period, and mean of the data used to calculate the precision of the BAM PM<sub>10</sub> data at the representative site, Angiola.

No. of Data Points Used	Time Period	Mean	Precision
6	11/23/00 1400 – 2000 PST	38.5 µg/m <sup>3</sup>	5.4%

## 6. REFERENCES

- Bush D., Baxter R., and Yoho D. (2002) Final quality assurance audit report - California Regional PM<sub>2.5</sub>/PM<sub>10</sub> Air Quality Study (CRPAQS). Prepared for San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, by Parsons Engineering Science, Inc., Pasadena, CA, June.
- Hafner H.R., Hyslop N.P., and Green C.N. (2003) California Regional PM<sub>10</sub>/PM<sub>2.5</sub> Air Quality Study management of anchor site data. Prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, by Sonoma Technology, Inc., Petaluma, CA, 999242-2087-FR (scheduled for publication May 2003).
- Watson J.G., DuBois D.W., DeMandel R., Kaduwela A., Magliano K., McDade C., Mueller P.K., Ranzieri A., Roth P.M., and Tanrikulu S. (1998) Aerometric monitoring program plan for the California Regional PM<sub>2.5</sub>/PM<sub>10</sub> Air Quality Study. Draft report prepared for the California Regional PM<sub>10</sub>/PM<sub>2.5</sub> Air Quality Study Technical Committee, California Air Resources Board, Sacramento, CA, by Desert Research Institute, Reno, NV, DRI Document No. 9801.1D5, December.
- Wittig A.E., Blumenthal D.L., Roberts P.T., and Hyslop N.P. (2003) California Regional PM<sub>10</sub>/PM<sub>2.5</sub> Air Quality Study anchor site measurements and operations. Final report prepared for the San Joaquin Valleywide Air Pollution Study Agency c/o California Air Resources Board, Sacramento, CA, Sonoma Technology, Inc., Petaluma, CA, STI-999231-2332-FR (scheduled for publication May 2003).